

**A novel barley  $\beta$ -glucan extract (Glucage<sup>TM</sup>) in combination with flax or coconut oil influences cholesterol and triglyceride levels in growing rats**

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**Summary**

A 2 x 2 factorial arrangement of treatments was used to test the hypothesis that inclusion of a novel  $\beta$ -glucan extract (Glucage<sup>TM</sup>) in cholesterol-free synthetic diets containing coconut oil or flax oil would lower circulating total cholesterol (TC) and triglyceride (TG) levels in growing rats. Inclusion of Glucage<sup>TM</sup> (100 g/kg) tended to decrease TC levels ( $P=0.07$ ), however TC level was not influenced by oil type ( $P>0.05$ ). A significant interaction ( $P<0.05$ ) occurred for TG levels, with the addition of  $\beta$ -glucan to diets containing coconut oil and flax oil decreasing TG levels by 40% ( $P<0.01$ ) and 13% ( $P>0.05$ ), respectively. Faecal digestibility of fat was reduced by 7% ( $P=0.08$ ) in rats fed coconut oil plus  $\beta$ -glucan. These data suggest that reduced TG levels caused by addition of  $\beta$ -glucan may be mediated in part by reduced fat digestion in the small intestine, an effect most likely caused by the unique gel-forming properties of Glucage<sup>TM</sup>.

**Introduction**

High levels of total cholesterol (TC) and low-density lipoprotein (LDL) cholesterol are recognised as significant risk factors for human cardiovascular disease. The ability of several dietary fibre sources, such as  $\beta$ -glucan from barley, to lower plasma cholesterol levels, especially those that are water soluble, has been demonstrated previously. Barley fed to rats has been reported to lower TC and LDL concentrations (1), while the inclusion of  $\beta$ -glucanase in diets for rats reversed the hypocholesterolemic effects of barley (2). This supports the notion that soluble  $\beta$ -glucan is the component responsible for these cholesterol-lowering properties. Some dietary lipids may also regulate TC levels. In general, studies have shown that saturated fatty acids (SFA) raise TC levels and high levels of polyunsaturated fatty acids (PUFA) reduce the (mainly) high-density lipoprotein (HDL) cholesterol (3).

The effects of a  $\beta$ -glucan extract (Glucage<sup>TM</sup>) obtained from New Zealand barley were evaluated in this study by including it as the only source of soluble fibre in synthetic diets fed to growing rats. In addition, the effect of coconut oil, a rich source of SFA, and flax oil, a source rich in PUFA, on plasma TC and TG levels were also evaluated. The hypotheses tested in this study were twofold: (i) rats consuming diets containing  $\beta$ -glucan will have lower TC and TG levels, and (ii) TC levels of rats fed diets with coconut oil will be higher than those of rats fed diets containing flax oil.

### **Materials and Methods**

Thirty-six, 4-week-old male Sprague Dawley rats were allocated in a 2 x 2 factorial arrangement of treatments with factors being flax oil or coconut oil in the diet, and the presence or absence of Glucagel™. Treatments were assigned as follows: F100: Flax oil+β-glucan; F0: Flax oil minus β-glucan; C100: Coconut oil+β-glucan; and C0: Coconut oil minus β-glucan. The cholesterol-free synthetic diets were based on cornstarch and casein, with Glucagel™ added at 100 g/kg. Glucagel™ (4) is a white odourless powder containing 700 g/kg β-glucan. It has a low molecular weight, is partially depolymerised and, when dispersed in water, forms a soft gel (4). The oils used in the diets were New Zealand flax oil and imported coconut oil. The diets contained Cr<sub>2</sub>O<sub>3</sub> (3 g/kg) as a dietary marker.

Rats were housed individually in stainless steel, wire mesh cages in a controlled-temperature room having an ambient temperature of 22 ± 2° C, with a 12 hour light/dark reverse cycle. At 1700 hours on the day before the experiment commenced, all feed was withdrawn, rats were fasted for the next 16 h, and then bled (1 ml) from the tail vein for baseline measurements. Rats were fed the experimental diets in stainless-steel feeders for 26 d. During the last five days, samples of faeces were carefully collected from the floor of each rat's cage and immediately frozen at -20° C. On d 25 of the trial, all rats were fasted from 1700 until 0900 h the following day (d 26), at which time all rats were bled again.

Blood samples were centrifuged and TC and TG were assayed. Crude fat content of the diet and pooled faeces samples was determined using Soxhlet extraction with toluene. All samples were analysed for chromium content. A linear model with the fixed effects of oil type (coconut vs. flax), β-glucan (minus vs. plus), and their interaction was fitted to the data using the GLM procedure of SAS.

### **Results**

Total cholesterol levels in blood decreased about 10% with β-glucan (1.58 vs. 1.76 mmol/L, P=0.07). The type of oil fed had no significant effect on the plasma levels of TC in rats. A significant interaction (P<0.05) existed between β-glucan level and the type of oil added to diets for TG levels. In diets with coconut oil, addition of β-glucan decreased TG levels by 40% (P<0.001). In diets containing flax oil, β-glucan inclusion reduced TG levels by 13% (P>0.05). Rats fed diet F0 had lower TG levels than rats fed diet C0 (P<0.001). The same trend was observed for coconut and flax oil diets containing β-glucan (P=0.053) (Table 1).

An interaction (P=0.08) existed between β-glucan inclusion and the oil type added for faecal fat digestibility. Addition of β-glucan to diets with coconut oil reduced faecal fat digestibility by 7.6 %, whereas addition of β-glucan to diets containing flax oil had no influence on fat digestibility (Table 2).

Table 1: Least-squares interaction means for total cholesterol (TC) and triglyceride (TG) levels in plasma of rats fed different diets (see text for details)

	Diet				RSD <sup>1</sup>
	F100	F0	C100	C0	
TC (mmol/l)	1.65	1.71	1.50	1.80	0.282
TG (mmol/L)	0.46 <sup>a</sup>	0.53 <sup>a</sup>	0.75 <sup>a</sup>	1.25 <sup>b</sup>	0.295

<sup>1</sup>RSD - residual standard deviation.

<sup>a,b</sup> Within rows, values not having the same superscript are significantly different (\*P<0.05)

Table 2: Least-squares interaction means for faecal digestibility of fat of rats fed different

	Diet				RSD <sup>1</sup>
	F100	F0	C100	C0	
Digestibility, %	93.6	94.5	89.6	97.2	3.17

<sup>1</sup>RSD - residual standard deviation.

### Discussion

The addition of Glucagel™ to a cholesterol-free synthetic diet decreased the levels of TC in the plasma of growing rats by around 10% after 26 d of feeding, although this effect was significant only at the 7% level. These data support our hypothesis, and concur with other work demonstrating the hypocholesterolemic effect of soluble  $\beta$ -glucan (5). We proposed also that TC levels of rats fed diets containing coconut oil would be higher than those fed flax oil, but this was not supported. The fact that flax oil, a rich source of n-3 PUFA, did not have a significant effect on blood TC levels concurs with reports by other workers who showed that the major response to n-3 PUFA intake was a reduction in plasma TG levels but not TC levels (6). In the current experiment, rats fed coconut oil had higher ( $P<0.05$ ) levels of TG than those fed flax oil irrespective of Glucagel™ addition. Other workers (7) have found higher TG concentrations in the serum of rats fed coconut oil versus corn oil. Coconut oil is a rich source of lauric acid whereas flax oil is a rich source of  $\alpha$ -linoleic acid. In numerous metabolic studies, n-3 PUFA's have shown significant hypolipidemic effects, with the major response being a reduction in plasma TG levels (8).

Numerous mechanisms may explain how soluble  $\beta$ -glucan lowers serum cholesterol. These include binding of bile acids in the lumen, inhibition of HMG-CoA reductase in the liver by short-chain fatty acids, delayed gastric emptying, physico-chemical properties of the fibre sources, and interference with fat absorption by increased intestinal viscosity (9). Data from the current experiment, albeit on a small sample size, shows a reduction in faecal fat digestibility, especially in rats fed coconut oil, in the presence of  $\beta$ -glucan. In broiler chickens, the digestibility of saturated fats is decreased in the presence of soluble arabinoxylans. This can be circumvented by the addition of exogenous xylanases (13), suggesting that soluble fibre sources interfere with the process of emulsification, lipid digestion or absorption, or a combination of these factors. Increased viscosity, therefore, may be an important factor responsible for decreased lipid digestion and absorption (14). Gel formation has also been proposed as a mechanism that may delay lipid digestion and absorption (15). Gelling fibres may modify the resistance of the surface-associated unstirred water layer of the small intestine, which in turn can

influence nutrient flux and absorption. They may also interfere with the diffusion of lipid-containing micelles within the small intestine. Glucagel™ forms a soft gel rather than a viscous solution when mixed with water (4), such that the formation of this gel may be the primary factor responsible for the reductions in TC and TG of rats fed the diets containing Glucagel™.

#### Acknowledgements

The New Zealand Foundation for Research, Science and Technology provided funding for this trial.

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